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Visual Case Discussion

COVID-19 Personal Protective Equipment (PPE) for the emergency physician



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1. Introduction

In December 2019, a novel corona virus infection was detected in Wuhan, China, Hubei province. Initial cases all had a common link to an large seafood and live animal marketplace. Corona viruses are a broad class of viruses that are responsible for most of the common colds, as well as several viral illnesses transmitted from animals to humans. They are so-named due to their similar appearance under electron microscopy to the sun's corona during a total solar eclipse (see Figs. 1 and 2^{1,2}). The virus responsible for the current outbreak was originally called novel corona virus, now renamed SARS-CoV-2, since it is related to the SARS virus that caused an epidemic in China in 2002-2003 (postulated at that time to have originated in civet cats and then jumped to humans), and the MERS corona virus-related to transmission from camels <https://www.cdc.gov/coronavirus/2019-nCoV/summary.html>. The infection is now called COVID-19, and within a few weeks, it became clear that COVID-19 infection was easily spread from person to person, as there was an exponential rise in newly-reported cases seen in China. Travelers from China then spread the COVID-19 to other countries, causing the WHO to declare the epidemic a Global Health Emergency on January 30, 2020³. Simple recommendations of respiratory protection and glove use early on in the official guidance from health agencies contrasted sharply with wide coverage in the 24-hour news media, showing graphic pictures of civilian authorities and health

care personnel in Asian countries wearing extensive protective gear reminiscent of that used for Ebola or even hazmat incidents. While initially it was felt that droplet transmission was most the likely mode, recommendations have been upgraded to airborne and contact transmission, since the natural course of this infection is still not completely understood, infectivity or contagiousness seems higher than SARS, and people seem to be able to transmit infection before they ever become symptomatic, and for some days after seemingly full recovery (<https://www.cdc.gov/coronavirus/2019-ncov/about/transmission.html>) (Figs. 3⁴, 3a^{5,6}, 4a⁷).

2. Types of transmission and precautions^{8,9}

Emergency providers of patient care to persons with suspected COVID-19 infections or who will be in the same room or compartment with such patients should follow Standard, Contact, and Airborne Precautions, including the use of eye protection, as recommended by the CDC and WHO. Care should be in single isolated negative-pressure rooms. The following sections further explain these precautions.

3. Standard precautions¹⁰

The CDC defines standard precautions as common sense utilization of practices and PPE to protect healthcare workers from infections and

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¹ <https://www.cdc.gov/coronavirus/2019-ncov/index.html>

² <https://spaceplace.nasa.gov/sun-corona/en/>

³ <https://www.npr.org/sections/goatsandsoda/2020/01/30/798894428/who-declares-coronavirus-outbreak-a-global-health-emergency>

⁴ <https://blogs.cdc.gov/niosh-science-blog/2013/01/15/catchingtheflu/>

⁵ https://www.osha.gov/SLTC/mers/control_prevention.html

⁶ https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/respsource3healthcare.html

⁷ <https://www.facebook.com/RespiratorFITtest/>

⁸ <https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions.html>

⁹ <https://www.who.int/docs/default-source/coronaviruse/getting-workplace-ready-for-covid-19.pdf>

¹⁰ <https://www.cdc.gov/infectioncontrol/basics/standard-precautions.html>

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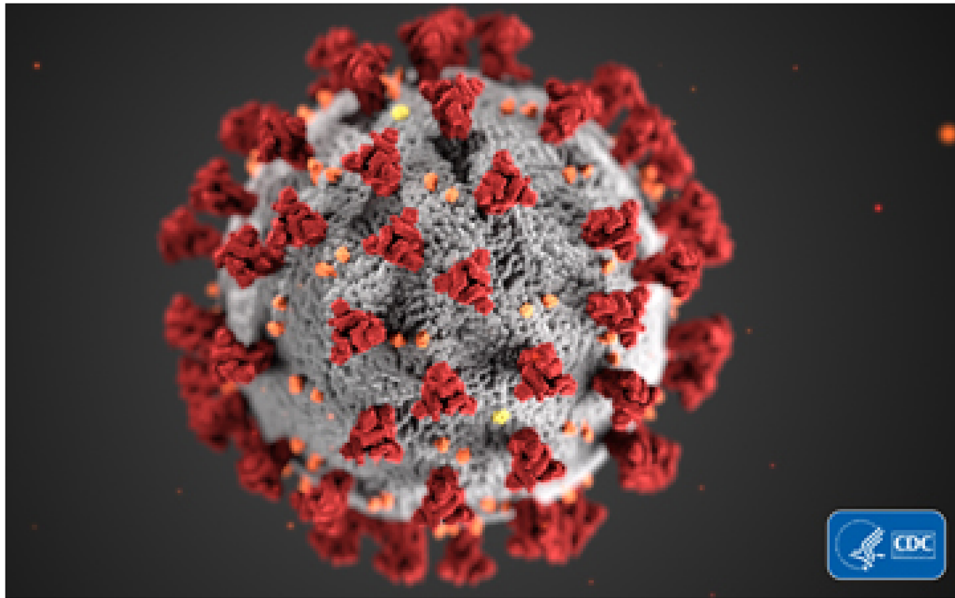


Fig. 1. Coronavirus- CDC.



Fig. 2. NASA: Sun's Corona during Solar Eclipse August 21, 2017.



Fig. 3a. NIOSH- Approved N95 mask (above) and N95 duck bill and other styles (below).



Fig. 3. CDC- airborne particles from a sneeze.

to prevent spread of infection from patient to patient. This includes respiratory hygiene and cough etiquette, proper patient placement/isolation, handling and cleaning of patient care equipment, devices, laundry, clothing, and environment; and sharps and procedure safety.

4. Contact transmission¹¹

Transmission of infection by skin-to-skin contact with an infected person, or by touching contaminated items from a person's room (fomites: patient care equipment, telephones, TV remote controls, countertops, as well as bedding, etc.). Wound drainage, as well as secretions or bodily fluids (vomitus, diarrhea, etc.) increase risks for contact transmission. Some notable pathogens transmitted by contact include norovirus, MRSA, *C. difficile*, VRE (vancomycin resistant enterococcus), CRE (carbapenem-resistant enterococcus), SARS, and MERS, among others.

¹¹ <https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions.html>



Fig. 4. face shield and N95 for airborne protection.

5. Respiratory transmission

Respiratory transmission of diseases can occur when people with certain infections talk, laugh, cough, sneeze, or sing. There are two types: droplet, and airborne.

6. Droplet¹²

Droplet transmission occurs when a patient coughs, sneezes, or talks, which generates infected droplets that can contact the eyes nose, or mouth of another person causing infection. These droplets are fairly large and do not remain airborne for long and settle out fairly quickly. Simply placing a disposable mask on the patient will reduce transmissibility to healthcare workers. Diseases transmitted by droplets are influenza, meningococcal disease, H. flu (HIB), mycoplasma, whooping cough, rubella, and mumps, among others.

Droplet particles are larger than those exhibiting airborne transmission (see below), and therefore simply maintaining a distance of at least 6 feet away from the patient may be adequate. Negative pressure rooms are not required, but patients are generally isolated in single-patient rooms. Disposable surgical masks and procedure masks are protective to healthcare workers for droplet transmission, but many institutions err on the side of caution and recommend N95 masks for prevention of any respiratory transmission. A recent study showed simple medical procedure mask use was just as effective as N95 respirator use for influenza prevention in the outpatient healthcare setting.¹³ While predominant thought is that the coronaviruses are transmitted via droplets (like influenza), the quick spread of this epidemic and contagiousness suggests airborne particles may be more possible (see below).

7. Airborne¹⁴

Airborne transmission refers to situations where smaller droplet nuclei or dust particles containing the pathogen can remain suspended in air for long periods of time (2 hours or more), and can travel a much



Fig. 4a. fit testing N95 mask with qualitative solutions (isoamyl acetate, saccharine, etc.).

greater distance from the patient, since they stay suspended longer. Patients with COVID-19 and other airborne transmissible diseases require negative pressure rooms. Other diseases exhibiting airborne transmission include TB, chicken pox (varicella), and measles. These diseases are much more transmissible than droplet, and a higher level of respiratory protection is needed. NIOSH recommends N95 respirators that have been properly fit-tested for all personnel caring for COVID-19 patients (see below).

8. Personal Protective Equipment (PPE)

8.1. Respiratory

N-95 respirators (see Fig 3 & Fig 3a & Fig. 4¹⁵) are required for airborne protection from COVID-19. Per OSHA regulations, HCW must be properly fit-tested with either a qualitative or quantitative device to ensure the mask makes a proper seal with the wearer's skin and offers adequate protection. Users must be clean shaven for mask use as well as for the fit test. Numerous brands are available from multiple manufacturers¹⁶(see photos from NIOSH website below). Users with beards cannot be fit tested with an N95, since an adequate seal is not possible¹⁷. HCW with beards can use a powered air-purifying respirator (PAPR) with a hood, since these function without the need for a tight skin seal and therefore also do not require fit testing (see photos).

N95 designation is from NIOSH, meaning it is actually a dust-mist respirator which filters out 95% of small particles, but is not resistant to oil (N = Not; 95 = 95% filtration efficiency). An R95 has the same filtering capacity but is recommended for oily solvents (R = recommended). Higher designations such as P100 mean they filter out 99.99% of particles (P = particles; 100 = essentially 100% efficiency). Higher levels of protection (i.e., R95, P100) are

¹² <https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions.html>

¹³ Radonovich LJ Jr, Simberkoff MS, et al; ResPECT investigators. N95 Respirators vs Medical Masks for Preventing Influenza Among Health Care Personnel: A Randomized Clinical Trial. *JAMA*. 2019 Sep 3;322(9):824-833. <https://www.ncbi.nlm.nih.gov/pubmed/31479137>

¹⁴ <https://www.cdc.gov/infectioncontrol/basics/transmission-based-precautions.html>

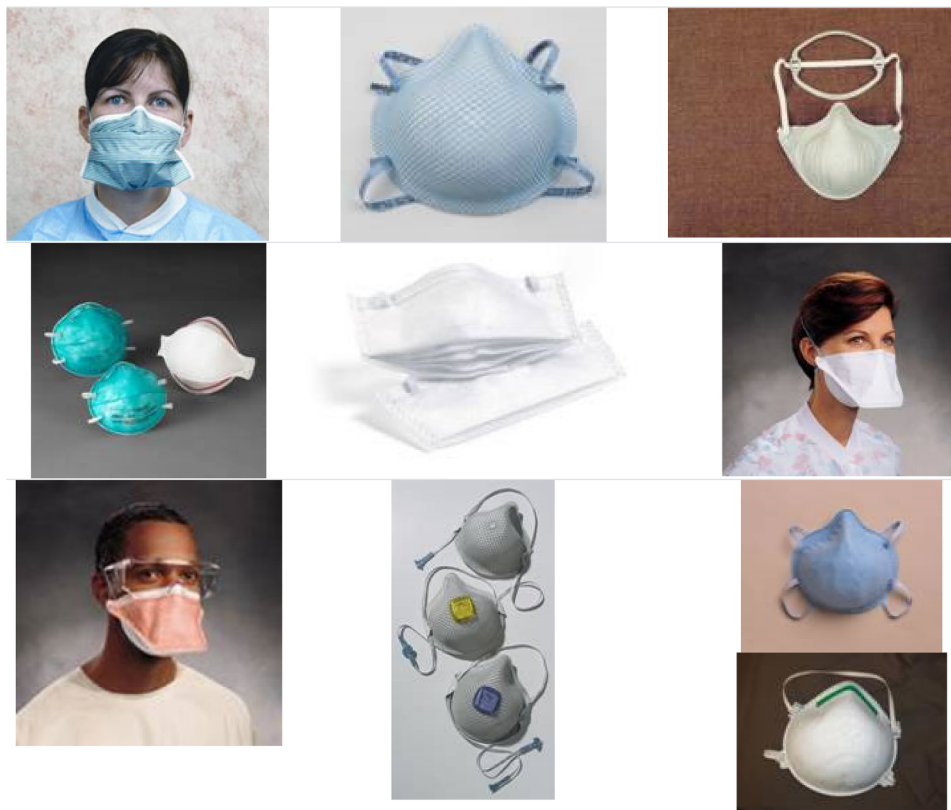
¹⁵ <http://www.sickkids.ca/Nursing/Education-and-learning/Nursing-Student-Orientation/module-one-safety/infection-control-at-sickkids/ppe/index.html>

¹⁶ https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/n95list1.html

¹⁷ <https://www.osha.gov/laws-regs/standardinterpretations/2016-05-09>

acceptable if a situation calls for N95 and an N95 is not available, but lower levels of protection (i.e., simple procedure or surgical mask) are not (Fig. 9).

Some of the styles of N95 masks available:



Photos courtesy of 3M, Kimberly-Clark, and Moldex¹⁸.

Since OSHA declares N95 masks for HCW as respirators, their use is governed by the OSHA Respiratory Protection Standard 1910.134¹⁹. Employers must have a program in place with the following components:

- Written worksite specific procedures;
- Program evaluation;
- Selection of an appropriate respirator approved by NIOSH
- Training
- Fit testing
- Inspection, cleaning, maintenance, and storage (for loose-fitting hoods- N/A to disposable single-use N95 masks)
- Medical evaluations

Paragraph 1910.134(e)(2)(i) of the standard explains that the medical evaluations are to be performed by a physician or other licensed health care professional (PLHCP) identified by the employer to perform medical evaluations using a medical questionnaire or an initial medical examination that obtains the same information as the medical questionnaire. The employer shall ensure that a follow-up medical examination is provided for an employee who gives a positive response to

any question among questions 1 through 8 in Section 2, Part A of Appendix C²⁰ or whose initial medical examination demonstrates the need for a follow-up medical examination. Questions 10-15 and all of part B regarding full-face respirators do not apply to HCW using N95 or loose fitting PAPR hoods. Since the N95 respirator is a negative pressure

respirator, if the PLHCP finds a medical condition that may place the employee's health at increased risk if the respirator is used, the employer shall provide a PAPR (such as the hood described above and pictured in Figs. 5 and 6²¹).

Fit testing for the N95 respirators is required, but can be performed qualitatively using isoamyl acetate (banana oi), saccharin solution, or Bitrex© Fig. 4a (see Fig. 4a), or quantitative using an approved device, such as Port-a-Count® (see Figs. 7 and 8)²². The fit test must be performed with exact make, model, and size of respirator the HCW with be using in the workplace. Qualitative testing does not compromise the mask integrity and therefore after the test the employee can take the N95 with them for future single use (important consideration in time of shortages). Quantitative fit tests require insertion of a probe through the mask, compromising mask integrity, and therefore the N95 must be discarded after a quantitative fit test. Fit testing is not required for loose-fitting PAPR hoods (which are used primarily by HCW with facial hair that does not allow a proper seal), because the breathing zone environment is under positive pressure and therefore a tight seal is not required for proper function and protection.

¹⁸ https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/respsource3healthcare.html

¹⁹ <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134>

²⁰ <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134AppC>

²¹ <https://www.cdc.gov/niosh/npptl/topics/respirators/factsheets/respsars.html>

²² <https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134AppA>



Fig. 5. .



Fig. 7. Fit testing N95 mask with PortaCount®.



Figs. 5 and 6. PAPR loose fitting hood with HEPA filters (no fit test required; suitable for bearded HCWs).

9. Contact²³

Contact PPE includes a single pair of disposable patient examination gloves. Change gloves if they become torn or heavily contaminated. A more conservative approach would include double gloving and frequent changing of outer gloves when soiled or torn, with full removal when at risk tasks are completed. In addition, a disposable isolation gown is required. Many facilities are using clothing that has a hood integrated into a zip-up gown or full jumpsuit-type clothing, with a face shield worn along with an N95; a procedure or surgical mask that has a built-in face shield could be worn over an N95 for the eye protection if goggles or face shields aren't available (see photos). All personnel must be mindful of not touching their face while working.



Fig. 8. Portacount® quantitative fit test device.

Upon completion of patient care activities in the negative pressure respiratory isolation room, clinicians should remove gown first, then mask and face shield, and discard PPE; then remove gloves and perform



Fig. 9. Simple procedure mask with integrated face shield (not an N95). Used by general public. This could be worn on top of N95 for eye protection.

²³ <https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-for-ems.html>

hand hygiene. Used PPE should be discarded in accordance with routine procedures.

Ancillary personnel (ambulance drivers, medics, and techs/aids who help move patients onto stretchers), should wear all above-recommended PPE. After completing patient care/transport duties, and before entering clean areas, personnel should remove and dispose of their PPE and perform hand hygiene to avoid contaminating clean areas.

In addition to the PPE described above, EMS clinicians should exercise caution if an aerosol-generating procedure, such as bag valve mask (BVM) ventilation, oropharyngeal suctioning, endotracheal intubation, nebulizer treatment, continuous positive airway pressure (CPAP), bi-phasic positive airway pressure (biPAP), or resuscitation involving emergency intubation or cardiopulmonary resuscitation (CPR) is necessary. BVMs, and other ventilatory equipment, should be equipped with HEPA filtration to filter expired air.